NGST Science

- Science Drivers
- NGST "8-m" Performance
- Overview of Science Instrument Module
- Science Working Group
- Draft Key Programs
- Plans & Issues

Science Drivers
(post-Group 1 Trades, April 14, 1996)

- The "drivers" are high level goals based on *HST & Beyond Committee* Recommendations.
- Distributed to SWG and SAC and put on NGST Web Page.
- Within the NASA study, they are used to drive the overall technical requirements for NGST.
- These drivers have been "stiffened" and used to inform NASA-HQ about the NGST science mission and its unique capabilities.

Priority Setting of Science Programs and Capabilities

- Priority 1 are unique NGST mission objectives and are central to the success of NGST. Design NGST around these capabilities.
- Priority 2 are very important to the NGST science mission. Include unless the cost is too high.
- Priority 3 are competitive with future ground and space-based capabilities. Keep if low cost.
- Priority 4 would extend foreseeable capabilities but are not recommended at this time.

Priority 1

• Zodiacal-light limited imaging performance (1-5 microns) to study early galaxies.	> Requires T_optics < 70 K, HEO or L2 orbit, capable of pointing 60-70 degrees from sunline to minimize zodiacal light
• Sensitivity to observe newly formed globular clusters at z=5-9 (1.4nJy in 10^4 s 10 sigma)	> Requires minimum of 12m^2 aperture, more likely a 30-40 m^2 aperture
• A 1.5 yr survey program and 3.5 yr GO program in NIR & TIR	> Requires adequate expendables
• Obtain statistically significant number of sources in 1.5yr survey	> Requires large FOV & arrays (>3x3 arcmin, 4096x4096)

Priority 1 (Cont.)

• Ability to obtain follow-spectroscopy (redshifts and energy distributions of 10 sigma survey sources (1-5 microns, R=100-1000)	>Large collecting area and low noise 2D detectors, efficient fiber, microlens, or slicer optics
• Imaging performance at 2 microns equivalent to HST to avoid confusion in deep field surveys.	> ~8m baseline, 60 mas FWHM

Priority 2

• Background limited-multipurpose Thermal IR (TIR)capabilities from 5-microns to 20microns to followup SIRTF discoveries, very high-z QSOs

> Low noise detectors (5-30microns) with active cooling, emphasizes thermal design and
low instrument bay temperatures.

• Wide Field-Imaging capabilities in the visible to permit ID of foreground galaxies.

> Requires CCDs or similar detectors. Gold coatings, overcoated silver would be better.

• All sky-pointing, at least once per year to permit first rank GO program

> Requires large sun-shield, and pointing perpendicular to sun-line.

• Ability to revisit selected fields over 2.5 months to followup Supernovae .

> Impacts sun-shield design

Priority 2 (Cont.)

Provide for focused studies after the initial deep surveys and follow-up after publications of three cycles of GO programs.	>10 year mission goal.
Ability to obtain R=1000 spectroscopy of z=5 galaxies and 5 sigma survey sources.	>Emphasizes larger collecting areas, 8m goal.

Priority 3

• Moderate Resolution Near-IR Spectroscopy to study earliest AGN at z=7-10 and velocity dispersions of galaxies at z=5 (2.5-5 microns, R=5-10,000, no overlap with ground capabilities in these near-thermal wavelengths).

> May require additional spectrographic channel and detector.

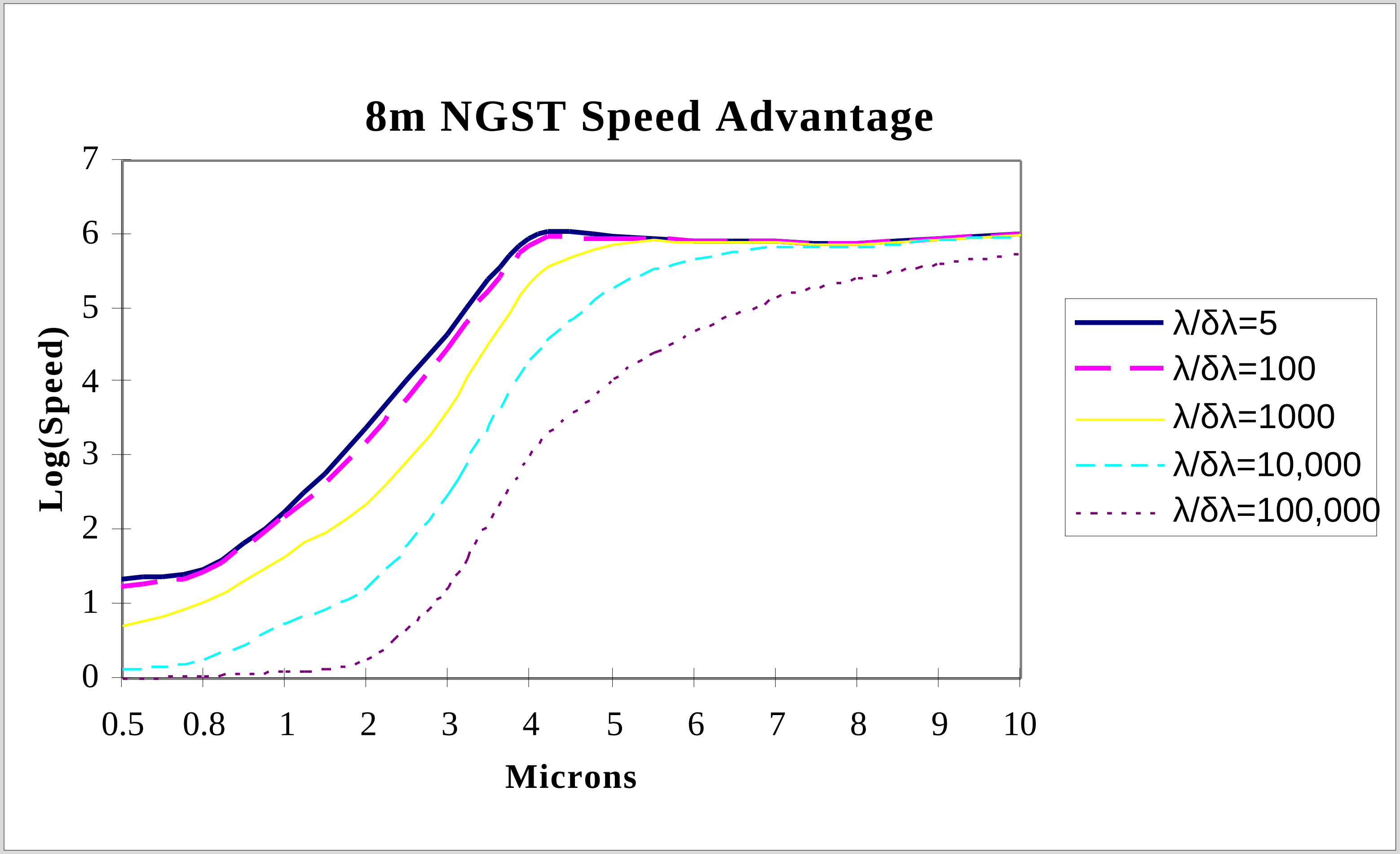
• Mid-IR Coronagraphy: Unique capability for use in detecting large planets and thermal emission due to dust in possible exostellar solar systems.

> May require additional imaging channel and detector.

Priority 4
(Not Recommended)

• Extension to UV (<0.3 microns; extends HST coverage of this region)	> Contamination issues, additional channels and detectors, would require development of low-temp UV detectors if solar blind.
• Extension to Far-IR (>50 microns)	> Competes with FIRST & MM Arrays, poor use of limited FOV, Needs additional active cooling
• High Resolution near-IR spectroscopy(1-5 microns, R=100,000)	> Ground-based facilities will develop these for working between the atmospheric lines.

Priorities agree with Speed Advantage (ground/ngst)

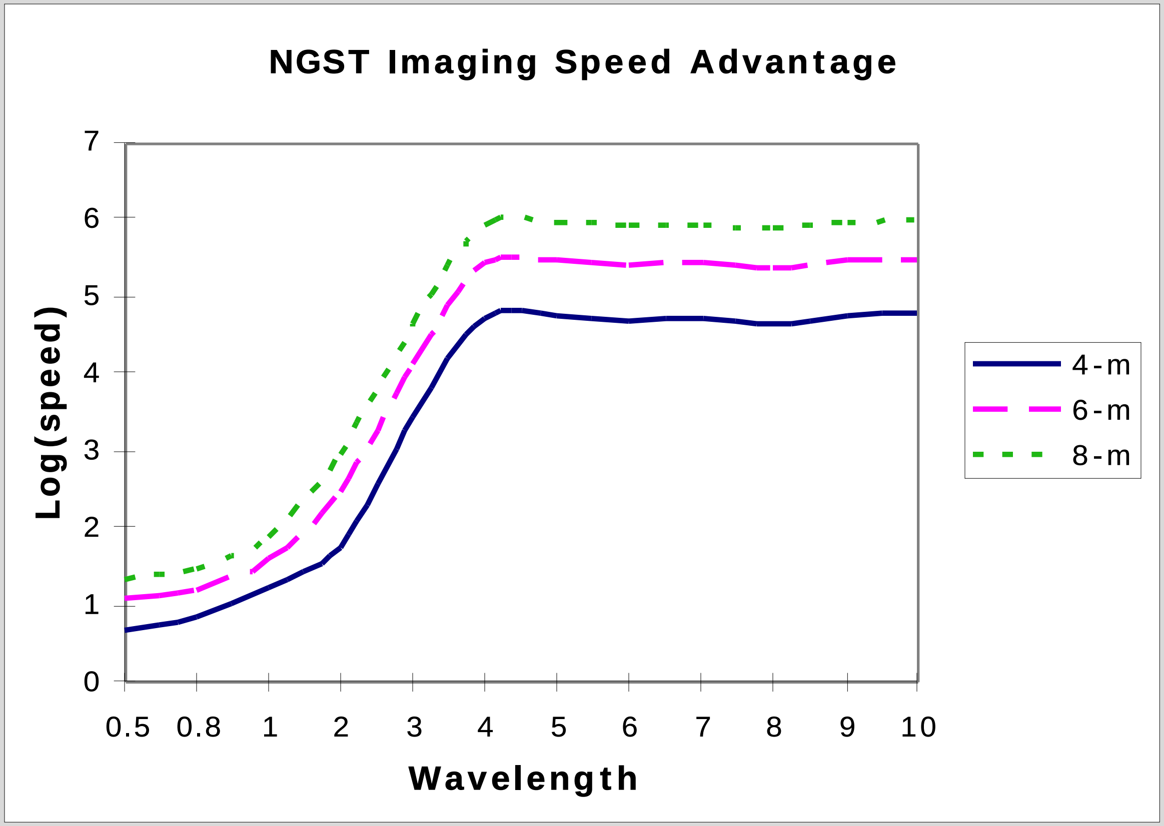


NGST

SAC Meeting
8-9 July 1996

Larger Aperture Size shifts Speed Advantage to Shorter Wavelengths

- 8-m: 100x faster above 1.0 micron
- 4-m: 100x faster above 2.2 micron
- Assumes 60mas resolution at 1,1.5, or 2 microns



8-m Sensitivity Estimates

- Assumes 7.3m effective circular aperture
- Zodiacal Light based upon IRAS measurements
- 1000 s read times based on 5-10% hits by cosmic rays (1 GeV particles hard to shield against)
- Reasonable improvements in detectors
  - » InSb: 0.02e/pixel/s, 4 e RMS readnoise
  - » SiBIB: 10e/pixel/s, 8e RMS readnoise
- Overcoated silver (97% reflectivity); current QEs for InSb and SiBIB.

Near Infrared Imager

- Core instrument is a 4'x4' (2x2 4096x4096) NIR imager.
  - » Each camera channel has independent filter wheel (includes about 6 common filters).
  - » One of the camera channels must be used for the fine guidance sensor, but only 1/16 of imager is "lost" to guiding.

NIR & TIR Spectrographs

- NIR spectrograph uses a 4096x4096 imager &Texas Instrument addressable micro mirror matrix to permit multi-aperture spectroscopy; also "hunt and shoot" spectroscopy.
- The Thermal IR Camera/Spectrograph uses a 1024x1024 SiBIB detector, critically sampled at 9 microns.

Science Working Group -- Status

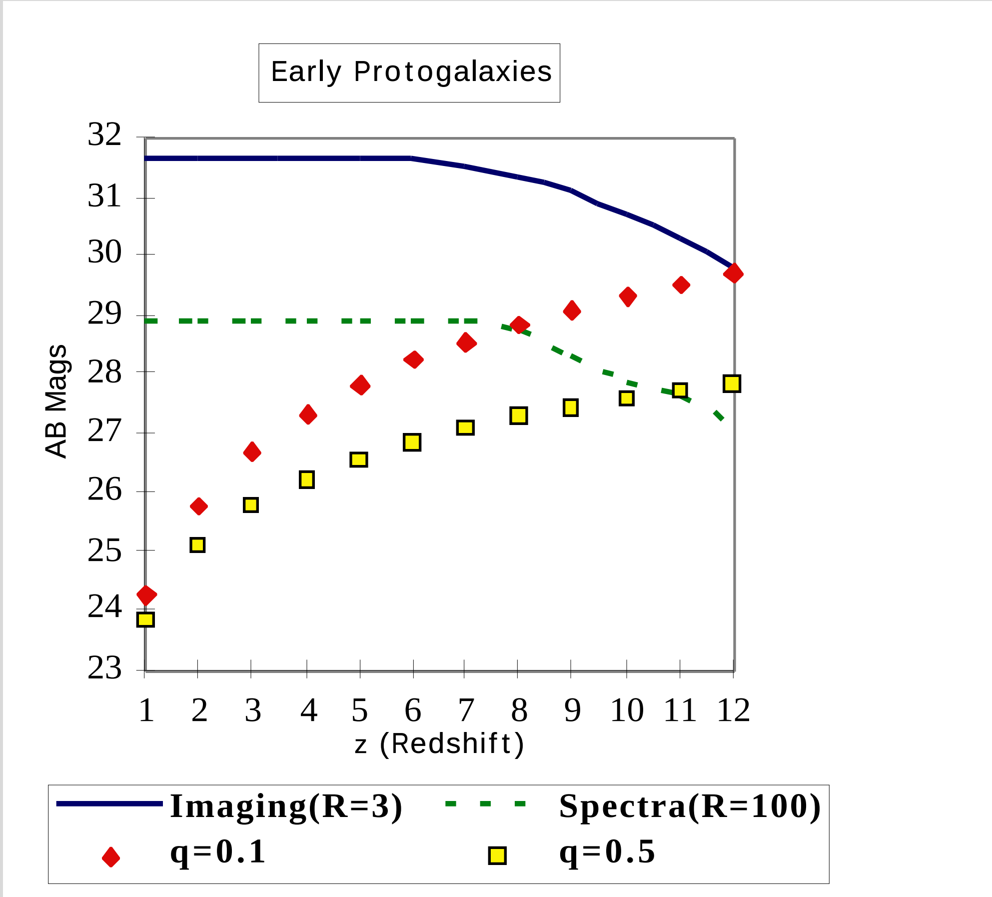
- Approximately 60 people are now enlisted in the SWG and are organized into 10 teams.
- Hoping that more concrete mission design and the outcome of the CAN process will bring more interest from non-Balt/Wash. members.

  » High-z galaxies (Ferguson)
  » Supernovae (Perlmutter)
  » QSOs (Peterson)
  » Stellar Pops(Rich)
  » Stars& Planets(Noll)
  » Optics (no lead, despite efforts).
  » Instrument Module(Stockman)
  » Spacecraft(no lead)
  » Operations (Gull)
  » Simulations (Stiavelli)

Studying the Origins of Stars & Galaxies

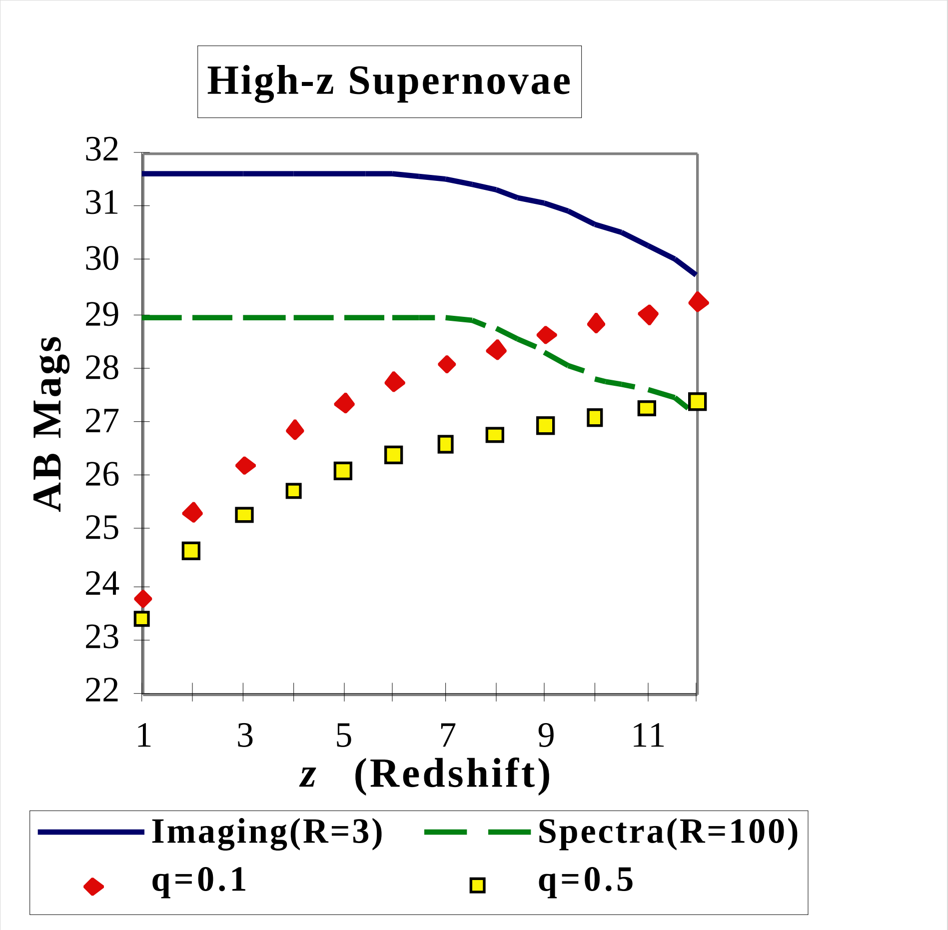
- Extensive NIR studies of galaxies at z=1-3
- Low res. redshift survey of 50,000 galaxies to a redshift of z=4.
- Observing Protogalaxies at z=10-12.
- angular density (#/str-dz)

$\rho(\Omega=0.2,10)/\rho(\Omega=1,10)$ 30

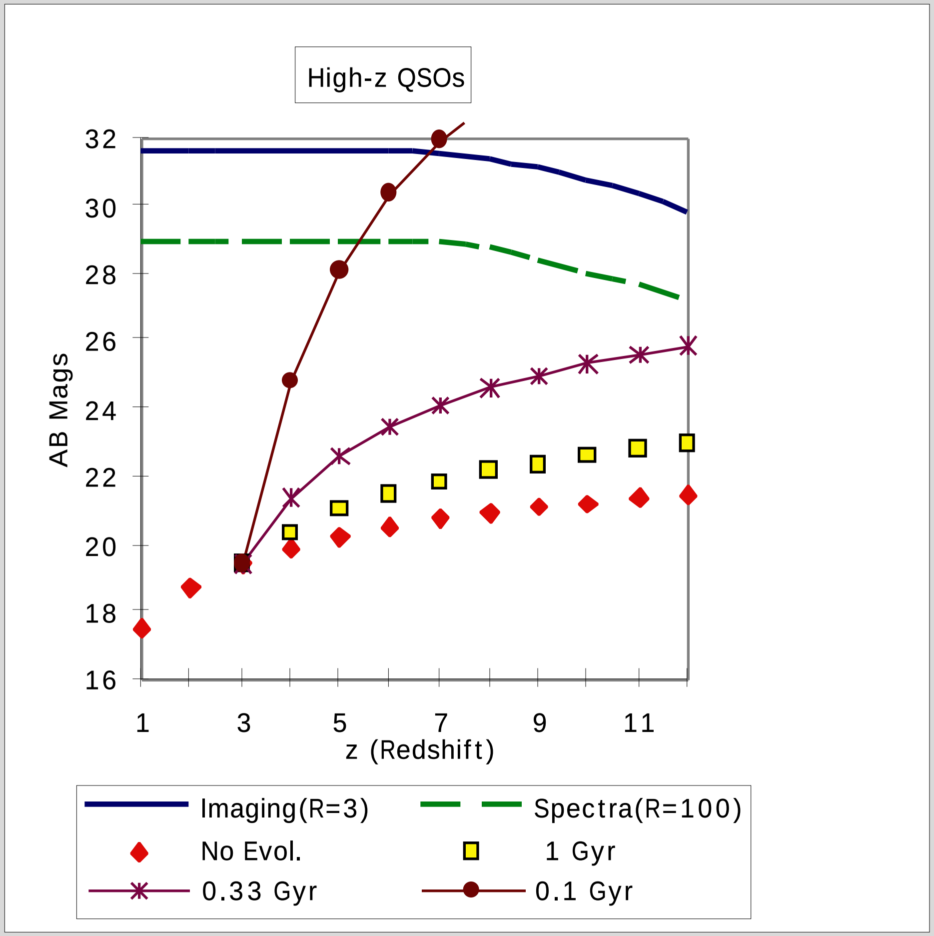


Studying Cosmology using High-Z Supernovae

- NGST has advantages of sensitivity, resolution, and stable PSF for discovering SNe 1as between z=1.5-4.
- For redshifts as high as z=8-9, fields would need to be revisited every year to discover new sources and follow the decline.
- For Ω=1, z=4,we get ~0.6 per sq deg-dz-visit for SNe 1a's in L* ellipticals(vs ~20-30 at z= 0.5)



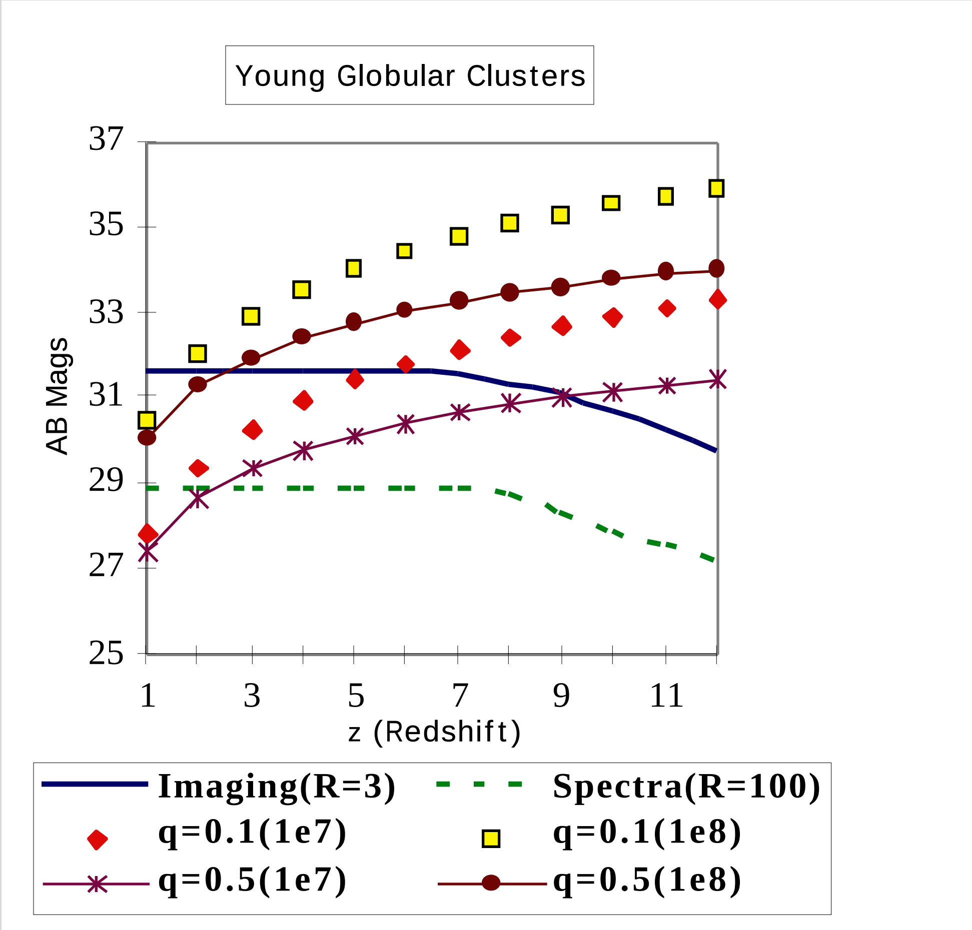
Study Early Evolution of QSOs



- QSOs luminosity function is seen to peak at z = 3.
- Assuming this represents the end of exponential growth, we can predict the apparent magnitude for a bright QSO (M_B=-26) for Ω=1, H =50.
- But also note that the apparent angular density will be low! (~1 per sq. degree). However, going 3 mags fainter gains a factor of >100.

Study formation of Globular Clusters (1<z<7)

- HST observations suggest that galaxy mergers and collisions create compact regions of star formation: early globular clusters.
- NGST can detect regions of intense star formation (1e6 solar masses) for 10-100 million yrs after their formation.



Understanding the Fossil Record of Galaxy Formation

- HST (with WFPC2 and ACS) will be capable of studying the stellar populations of the Local neighborhood (LMC and the Milky Way.)
- Req. resolution and wide field favor NGST, even in the visible and Vis-NIR.
- Assumes that HB and AGB studies can be calibrated for dense or distant sources.

- NGST Program
  - » Globular clusters & spheroids, disks in M31& M32.
  - » Outer halos in the Virgo Cluster, M81, CenA
  - » HB, subgiants, AGB would be visible to Coma, given very long exposure times (1week).

Studying Disks as a fossil record of Star & Planet Formation

- NGST could provide unique capabilities for characterizing the thermal emission from exo-zodiacal disks at 10 microns using a simple coronagraph. It would also be capable of detecting the thermal emission of sub-Jupiter sized planets at > 3 AU in very nearby systems (< 3-5 parsecs).

- In the NIR, NGST would study the distribution of large Kuiper Belt (KB) objects from 35-100AU.
  - » Two color survey to identify very red candidates (R,K)
  - » Follow-up spectroscopy of brighter KB sources
  - » Study density distribution vs. R & Z

Near Term Plans for SWG

- Invite SWG to 2nd Architecture Review and final report presentations.
- Improve Science Programs for Study Report (15 Aug.).
- Utilize SWG to provide material for Interim (post-integration) report (15 Sept-Nov.)
- Improve simulations both on Web and within the Science teams.
- Solicit membership from new IR Detector PIs.

SWG & SAC Issues

- Need better and broader SWG involvement.
  - » More technical detail & capability simulations
  - » Post-integration mission will be stronger
  - » Incorporate science leadership on CAN teams
- The science integration process may be difficult
  - » The CAN rules allow for the creation of many different missions and objectives.
  - » How do we handle new capabilities which do not fit in the post-integration mission?
  - » How do we "integrate" the 3 NGST science missions? What are the criteria?